

Docket No. 520.45750X00
Serial No. 10/562,643
Office Action dated July 13, 2007

REMARKS

The present Amendment does not add, amend, or cancel any claims. Accordingly, claims 1-6 remain pending in the application. Claims 1-6 are independent.

In the Office Action of July 13, 2007, the Title of the invention was objected to as non-descriptive. The Office Action further required submission of a new title that is clearly indicative of the invention to which the claims are directed.

By the present Amendment, Applicants have revised the title of the invention to recite "Magnetic Resonance Apparatus Utilizing Time-Varying Rate Of Magnetic Resonant Frequency." This title is believed to be clearly indicative of the invention to which the claims are directed.

Withdrawal of this objection is therefore respectfully requested.

Claims 1-6 were rejected under 35 USC §102(e) as being anticipated by U.S. Patent Application No. 2005/0033153 to Moriguchi et al. ("Moriguchi"). Claims 1-6 were also rejected under 35 USC §102(e) as being anticipated by U.S. Patent No. 7,042,215 to Moriguchi et al. (subsequently issued patent). In concert with the Office Action, the rejections will be addressed with respect to the published application.

In rejecting claim 1, the Office Action alleges that Moriguchi discloses a magnetic resonance imaging system that comprises all of the features recited therein. In particular, the Office Action alleges that Moriguchi discloses a sequence control means that includes control to irradiate the target with RF magnetic field, measure the magnetic resonance signal generated after the irradiation of the RF magnetic field in a state in which the strength of the application of the gradient magnetic field is approximately zero, and to calculate magnetic resonance spectrum

Docket No. 520.45750X00
Serial No.10/562,643
Office Action dated July 13, 2007

information from the measured magnetic resonance signal to thereby perform a magnetic resonance spectrum measurement. The Office Action directs reference to Figs. 1 and 9, paragraphs [0007] to [0014], and paragraphs [0082] to [0084]. The Office Action further states "the Examiner notes that Fig. 1 shows that the 1st and 2nd or more RF pulses applied may occur when the gradient is approximately zero because no gradients are indicated as being present in Fig. 1." See page 3, lines 19-21 of the Office Action.

At the outset, Applicants note that review of the cited passages has failed to reveal any disclosure, or even suggestion, of the allegations made in the Office Action. The fact that no gradients are shown in Fig. 1 is not an indication that the gradient magnetic field is zero. Rather, it is merely indicative of the fact that no gradients are shown in the figure. More appropriately, Fig. 1 illustrates only the RF and echo signals and simply omits the gradient magnetic field. Moriguchi specifically indicates that the first data component 22 is acquired in response to an initial pulse of RF energy. The second data set 14 has a similar initiation pulse 22 which is followed by a delay period. The third data set 18 includes the same initiation pulse 22 and a similar echo data component. See paragraph [0030].

Moriguchi indicates that a spiral off-resonance correction method with only one acquisition is used. In this method, odd and even numbered spiral interleaves have a different TE, and the central portion of K-space is oversampled using variable-density spiral trajectories. A B₀ inhomogeneity field map can be calculated by taking the phase difference between the two low resolution reconstructed from the data of odd and even numbered interleaves. See paragraph [0056]. Moriguchi discloses that K-space trajectories of the spiral 3PD and the spiral 2PD in Figs. 5A and 5B have three times and two times higher sampling densities than the outer

Docket No. 520.45750X00
Serial No.10/562,643
Office Action dated July 13, 2007

parts. Since the K-space trajectories are spiral shaped, the read out gradient magnetic field is applied with the modulation of the field strength during measurement of the magnetic resonance signal. It should be clearly apparent that the gradient magnetic field being applied cannot be zero, as alleged in the Office Action.

Next, the Office Action alleges that the sequence control means calculates a time-varying rate of the magnetic resonant frequency of water and directs attention to paragraphs [0038] and [0081]. Furthermore, the Office Action concludes that this limitation is met based on disclosure of "a deblurred water only image." See page 4, lines 7-9 of the Office Action.

This appears to be a misinterpretation of the reference. While Moriguchi discloses the use of multiple demodulation frequencies, these frequencies are not time-varying. Rather, these frequencies are obtained from the original frequency maps. Two parallel operations are performed wherein one process generates a deblurred water image from the acquired data while the other process generates a deblurred fat image from the acquired data. See paragraph [0033]. The demodulation frequencies used to deblur the water image are the same frequencies indicated in the frequency map, while the demodulation frequencies used to deblur the fat image are the sum of the chemical-shift off-resonance frequency and local frequencies that are indicated on the same frequency map. See paragraph [0038]. No calculations are performed using a time-varying rate of the magnetic resonant frequency of water. Moriguchi simply fails to provide any disclosure for features recited in independent claim 1, such as:

wherein the sequence control means includes control to irradiate the target with the RF magnetic field at least once,

Docket No. 520.45750X00
Serial No.10/562,643
Office Action dated July 13, 2007

measure the magnetic resonance signal generated after the irradiation of the RF magnetic field in a state in which the strength of application of the gradient magnetic field is approximately zero, and calculate magnetic resonance spectrum information from the measured magnetic resonance signal to thereby perform a magnetic resonance spectrum measurement, and

wherein the sequence control means performs control (1) to measure a first magnetic resonance signal generated from a measurement voxel at the magnetic resonance spectrum measurement at a first time interval, (2) to detect a magnetic resonant frequency F1 of water from a first magnetic resonance spectrum obtained by Fourier-transforming the first magnetic resonance signal, (3) to measure a second magnetic resonance signal generated from the voxel at a second time interval subsequent to the elapse of a predetermined time from the measurement of the first magnetic resonance signal, (4) to detect a magnetic resonant frequency F2 of water from a second magnetic resonance spectrum obtained by Fourier-transforming the second magnetic resonance signal, and (5) to calculate a time-varying rate of the magnetic resonant frequency of water on the basis of the F1 and F2.

It is therefore respectfully submitted that independent claim 1 is allowable over the art of record.

Independent claim 2 discloses a magnetic resonance imaging system that comprises:

- means which generates a static magnetic field;
- gradient magnetic field generating means which generates a gradient magnetic field;
- RF magnetic field generating means which generates an RF magnetic field;
- measuring means which measures a magnetic resonance signal generated from a target;
- computing means which performs a computation on the magnetic resonance signal;
- memory means which stores the magnetic resonance signal and the result of computation by the computing means; and
- sequence control means which sets operating conditions to respective portions of the gradient magnetic field generating means, the RF magnetic field generating means, the measuring

Docket No. 520,457,50X00
Serial No. 10/562,643
Office Action dated July 13, 2007

means, the computing means and the memory means to control the operations of the respective portions,

wherein the sequence control means includes control to irradiate the target with the RF magnetic field at least once, measure the magnetic resonance signal generated after the irradiation of the RF magnetic field in a state in which the strength of application of the gradient magnetic field is approximately zero, and calculate magnetic resonance spectrum information from the measured magnetic resonance signal to thereby perform a magnetic resonance spectrum measurement, and

wherein the sequence control means performs control (1) to measure a first magnetic resonance signal generated from a measurement voxel at the magnetic resonance spectrum measurement at a first time interval, (2) to detect a magnetic resonant frequency F1 of water from a first magnetic resonance spectrum obtained by Fourier-transforming the first magnetic resonance signal, (3) to measure a second magnetic resonance signal generated from the voxel at a second time interval subsequent to the elapse of a predetermined time from the measurement of the first magnetic resonance signal, (4) to detect a magnetic resonant frequency F2 of water from a second magnetic resonance spectrum obtained by Fourier-transforming the second magnetic resonance signal, (5) to estimate, based on the F1 and F2, a time-varying rate of a magnetic resonant frequency of water at a measurement time at which the magnetic resonance signal is measured after the completion of measurement of the second magnetic resonance signal, (6) to calculate, using the estimated time-varying rate of the magnetic resonant frequency, a transmission frequency of the RF magnetic field or/and a received frequency at which the magnetic resonance signal generated from the voxel is received and measure the magnetic resonance signal generated from the voxel after the setting of the operating conditions of the RF magnetic field generating means or/and the measuring means, and (7) to perform said (6) repeatedly plural times subsequently to the completion of measurement of the second magnetic resonance signal.

According to at least one feature of independent claim 2, a sequence control means includes control to irradiate the target with RF magnetic field at least once. Next, the sequence control means measures the magnetic resonance signal generated after irradiation of the RF magnetic field in a state in which the strength of application of the gradient magnetic field is approximately zero. The magnetic

Docket No. 520.45750X00
Serial No.10/562,643
Office Action dated July 13, 2007

resonance spectrum information is subsequently calculated from the measured magnetic resonance signal in order to perform a magnetic resonance spectrum measurement. Furthermore, the sequence control means, in part, estimates a time-varying rate of a magnetic resonant frequency of water at a measurement time at which the magnetic resonance signal is measured after completion of measurement of the 2nd magnetic resonance signal.

As previously discussed with respect to independent claim 1, Moriguchi fails to provide any disclosure for measuring the magnetic resonant signal generated after irradiation of the RF magnetic field in a state in which the strength of application of the gradient magnetic field is approximately zero. Additionally, Moriguchi fails to provide any disclosure for calculating a time-varying rate of a magnetic resonant frequency of water. Moriguchi is also completely silent on any type of estimation to that end.

It is therefore respectfully submitted that independent claim 2 is allowable over the art of record.

Independent claim 3 defines a magnetic resonance imaging system that comprises:

- means which generates a static magnetic field;
- gradient magnetic field generating means which generates a gradient magnetic field;
- RF magnetic field generating means which generates an RF magnetic field;
- measuring means which measures a magnetic resonance signal generated from a target;
- computing means which performs a computation on the magnetic resonance signal;
- memory means which stores the magnetic resonance signal and the result of computation by the computing means; and

Docket No. 520.45750X00
Serial No. 10/562,643
Office Action dated July 13, 2007

sequence control means which sets operating conditions to respective portions of the gradient magnetic field generating means, the RF magnetic field generating means, the measuring means, the computing means and the memory means to control the operations of the respective portions,

wherein the sequence control means includes control to irradiate the target with the RF magnetic field at least once, measure the magnetic resonance signal generated after the irradiation of the RF magnetic field in a state in which the strength of application of the gradient magnetic field is approximately zero, and calculate magnetic resonance spectrum information from the measured magnetic resonance signal to thereby perform a magnetic resonance spectrum measurement, and

wherein the sequence control means performs, when the measurement of the magnetic resonance signal is performed repeatedly plural times, control (1) to execute a pre-scan for measuring a magnetic resonant frequency of water each time the magnetic resonance signal is measured a predetermined number of times, (2) to detect a magnetic resonant frequency of water from a magnetic resonance spectrum obtained by Fourier-transforming the magnetic resonance signal obtained by the pre-scan, and (3) to set, based on the magnetic resonant frequency detected in said (2), a transmission frequency of the RF magnetic field radiated into the target or/and a received frequency at the measurement of the magnetic resonance signal in the spectrum measurement sequence executed subsequently to the pre-scan.

According to at least one feature of independent claim 3, the sequence control means measures the magnetic resonance signal generated after irradiation of the RF magnetic field in a state in which the strength of application of the gradient magnetic field is approximately zero. As previously discussed, this feature is clearly not shown by Moriguchi.

The Office Action further alleges, however, that Moriguchi discloses setting the transmission frequency of the RF magnetic field irradiated into the target based on the magnetic resonant frequency detected, and directs attention to substantially the entire reference. This appears to be a clear misinterpretation of the reference. Applicants' review of Moriguchi has failed to provide any disclosure, or even a shred

Docket No. 520.45750X00
Serial No.10/562,643
Office Action dated July 13, 2007

of suggestion, for setting the transmission/receive frequency based on the detected magnetic resonant frequency.

It is therefore respectfully submitted that independent claim 3 is allowable over the art of record.

Independent claim 4 defines a magnetic resonance imaging system that comprises:

- means which generates a static magnetic field;
- gradient magnetic field generating means which generates a gradient magnetic field;
- RF magnetic field generating means which generates an RF magnetic field;
- measuring means which measures a magnetic resonance signal generated from a target;
- computing means which performs a computation on the magnetic resonance signal;
- memory means which stores the magnetic resonance signal and the result of computation by the computing means; and
- sequence control means which sets operating conditions to respective portions of the gradient magnetic field generating means, the RF magnetic field generating means, the measuring means, the computing means and the memory means to control the operations of the respective portions,

wherein the sequence control means performs, when the measurement of the magnetic resonance signal is performed repeatedly plural times, control (1) to execute a pre-scan for measuring a magnetic resonant frequency of water each time the magnetic resonance signal is measured a predetermined number of times, (2) to detect a magnetic resonant frequency of water from a magnetic resonance spectrum obtained by Fourier-transforming the magnetic resonance signal obtained by the pre-scan, and (3) to set, based on the magnetic resonant frequency of water detected in said (2), a transmission frequency of the RF magnetic field radiated into the target or/and a received frequency at the measurement of the magnetic resonance signal in a pulse sequence executed subsequently to the pre-scan.

Similar to independent claim 3, the magnetic resonance imaging system sets the transmission and receive frequency based on the magnetic resonant frequency

Docket No. 520,45750X00
Serial No.10/562,643
Office Action dated July 13, 2007

of water detected. As previously discussed, this particular feature is not shown in the cited reference. It is therefore respectfully submitted that independent claim 4 is allowable over the art of record.

Independent claim 5 defines a magnetic resonance imaging system that comprises, in part:

wherein the sequence control means performs control (1) to execute a water suppression sequence for applying the RF magnetic field and the gradient magnetic field to the target to thereby suppress a signal of water, (2) to execute a spectrum measurement sequence for applying the RF magnetic field and the gradient magnetic field to the target to select and excite a predetermined voxel and measuring the magnetic resonance signal generated from the predetermined voxel, (3) to execute a pre-scan sequence for measuring a magnetic resonant frequency of water prior to said (1) and (2) being executed a predetermined number of times, where said (1) and (2) are performed repeatedly plural times, and (4) to, on the basis of the magnetic resonant frequency of water detected in said (3), set a transmission frequency of the RF magnetic field irradiated in the water suppression sequence and set a transmission frequency of the RF magnetic field irradiated to select and excite the predetermined voxel or/and a received frequency at the detection of the magnetic resonance signal generated from the predetermined voxel in the spectrum measurement sequence.

According to at least one feature of independent claim 5, the sequence control means executes a water suppression sequence for applying the RF magnetic field and the gradient magnetic field to the target in order to suppress the signal of water. Furthermore, the sequence control means sets a transmission frequency for the RF magnetic field that is irradiated in the water suppression sequence as well as the transmission frequency of the RF magnetic field in order to excite the predetermined voxel or received frequency at the detection of the magnetic resonant signal generated from the predetermined voxel in the spectrum measurement sequence.

Docket No. 520.45750X00
Serial No.10/562,643
Office Action dated July 13, 2007

The Office Action alleges that Moriguchi discloses these particular features. As previously discussed, Moriguchi generates the deblurred water image from the acquired data. There is no additional application of the RF magnetic field, particularly with respect to the gradient magnetic field, to further suppress the water signal. See paragraphs [0033] and [0038]. Furthermore, as previously discussed, Moriguchi is completely silent on setting the transmission and reception frequency of the RF magnetic field irradiated in the water suppression sequence.

It is therefore respectfully submitted that independent claim 5 is allowable over the art of record.

Independent claim 6 defines a magnetic resonance imaging system that comprises, in part:

wherein the sequence control means performs control (1) to execute a water suppression sequence for applying the RF magnetic field and the gradient magnetic field to the target to thereby suppress a signal of water, (2) to execute a spectrum measurement sequence for applying the RF magnetic field and the gradient magnetic field to the target to select and excite a predetermined voxel and measuring the magnetic resonance signal generated from the predetermined voxel, (3) to, when said (1) and (2) are performed repeatedly plural times, detect a water signal peak from a magnetic resonance spectrum obtained by Fourier-transforming the magnetic resonance signal obtained by the execution of said (1) and (2), each time said (1) and (2) are executed a predetermined number of times to calculate a signal strength of the water signal peak, (4) to determine that a magnetic resonant frequency of water has been shifted when the calculated signal strength of the water signal peak is increased to a predetermined value or more, (5) to execute a pre-scan for measuring the water magnetic resonant frequency when the water magnetic resonant frequency is judged to have been shifted in said (4), (6) to detect a magnetic resonant frequency of water from a magnetic resonance spectrum obtained by Fourier-transforming the magnetic resonance signal obtained in the pre-scan, and (7) to, in a pulse sequence executed subsequently to the pre-scan on the basis of the magnetic resonant frequency of water detected in said (6), set a transmission frequency of the RF magnetic field irradiated in the water suppression sequence, or/and set a transmission

Docket No. 520.45750X00
Serial No.10/562,643
Office Action dated July 13, 2007

frequency of the RF magnetic field irradiated to select and excite the predetermined voxel in the spectrum measurement sequence, or/and set a received frequency at the detection of the magnetic resonance signal generated from the predetermined voxel.

The magnetic resonance imaging system defined by independent claim 6 includes certain features that are somewhat similar to those recited in independent claim 5. For example, the sequence control means performs a water suppression sequence to apply the RF magnetic field and the gradient magnetic field to the target in order to suppress the signal of water. Additionally, the sequence control means sets the transmission frequency of the RF magnetic field irradiated in the water suppression sequence. As previously discussed, the art of record provides no disclosure, or even suggestion, for these particular features.

It is therefore respectfully submitted that independent claim 6 is allowable over the art of record.

For the reasons stated above, it is respectfully submitted that all of the pending claims are now in condition for allowance. Therefore, the issuance of a Notice of Allowance is believed in order, and courteously solicited.


If the Examiner believes that there are any matters which can be resolved by way of either a personal or telephone interview, the Examiner is invited to contact Applicants' undersigned attorney at the number indicated below.

Docket No. 520.45750X00
Serial No.10/562,643
Office Action dated July 13, 2007

AUTHORIZATION

Applicants request any shortage or excess in fees in connection with the filing of this paper, including extension of time fees, and for which no other form of payment is offered, be charged or credited to Deposit Account No. 01-2135 (Case: 520.45750X00).

Respectfully submitted,
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